

Application Number 10/823,483  
Amendment dated April 26, 2007  
Response to Office Action mailed December 27, 2006

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### Remarks/Arguments

Claims 1 – 14 are pending in the application. Claims 1 – 7 stand rejected under 35 USC 103(a) over Shakouri and Fitzpatrick; claims 8 and 9 stand rejected over Shakouri, Fitzpatrick and Richards; claims 10 – 14 stand rejected over Shakouri, Fitzpatrick and Huffman. Applicant respectfully traverses Examiner's rejection of claim 1 for the reasons set out below.

#### (A) Unsuggested combination

Shakouri teaches the use of bandgap engineering and modulation doping to fabricate small thermionic coolers that operate at room temperature (see column 1, lines 56 – 59). To this end a device is provided having a material 14 that serves to separate a cathode 12 and an anode layer 16, as shown in Fig. 3C and disclosed in column 6, line 64 – column 7, line 12. The thickness of layer 14 (28) is in the range 0.01 – 1 $\mu$ m (column 7, lines 48 – 50).

Fitzpatrick teaches that the distance between the two electrodes of a thermionic converter should be less than 5 $\mu$ m if the current density is increased above 10 A/cm<sup>2</sup> (page 921, column 1, last paragraph). The desirability of reducing the spacing between electrodes to as small as 2 $\mu$ m led to the development of a method for controlling the interelectrode gap which uses piezo-electric translators for actively maintaining the gap in the 2 – 5 $\mu$ m range.

Shakouri gives a range of values for the magnitude of 28, but offers no teaching concerning a preferred or optimal value. Furthermore, there is no teaching that adjusting the spacing between the electrodes would increase the efficiency and power density of the device, nor any other teaching suggesting any benefit for distance 28 being adjustable.

Thus Shakouri fails to provide teaching, suggestion or motivation to produce the claimed invention by combining the heat pump of Shakouri with the adjustable electrodes of Fitzpatrick, and therefore claim 1 is patentable.

#### (B) References Teach Away

Shakouri teaches the use of bandgap engineering and modulation doping to fabricate small thermionic coolers that operate at room temperature (see column 1, lines 56 – 59). To this end a

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device is provided having a material 14 that serves to separate a cathode 12 and an anode layer 16, as shown in Fig. 3C and disclosed in column 6, line 64 - column 7, line 12. The thickness of layer 14 (28) is in the range 0.01 – 1 $\mu$ m (column 7, lines 48 – 50).

Fitzpatrick teaches positioning means able to create a 2 – 5 $\mu$ m gap (page 921, column 1, last paragraph).

The operating range of Shakouri (0.01 – 1 $\mu$ m range) is incompatible with the solution offered by Fitzpatrick (2 – 5 $\mu$ m range); the adjustable electrodes of Fitzpatrick could not be used for controlling a significantly smaller gap than that enabled by the Fitzpatrick disclosure, and the references therefore teach away from the suggested combination.

Furthermore, Shakouri teaches both electron and hole thermionic emission from semiconductor materials to provide cooling at room temperatures, whilst Fitzpatrick teaches thermionic emission from a metal plate at elevated temperatures in excess of 1300K.

There is thus no motivation for the person of ordinary skill in the art to combine the two references to obtain the present invention.

#### **(C) References Complete**

Shakouri discloses a device that enables both electron and hole thermionic emission to cool electronic components, and offers a simple layered approach for such devices. There is no suggestion in the disclosure that the invention is incomplete or sub-optimal, or that aspects of its fabrication or operation are close to or beyond the capabilities of the art at the time the invention was made. Certainly there is no indication that control of 28 would offer improved operating performance.

#### **(D) Impossible to Combine**

It is difficult to see how the actuator of Fitzpatrick might be incorporated into the device of Shakouri. The most obvious approach would be consider the embodiment shown in Fig. 3E, and replace 14 with piezo-electric elements to maintain the vacuum gap (14A). However, as disclosed above, the size of the vacuum gap is in the 0.01 – 1 $\mu$ m range, which means the piezo electric devices used to maintain the gap would need to be a similar size. Although no

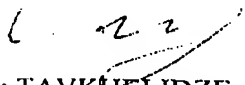
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dimensions are given in Fitzpatrick, it is clear that the piezo-electric actuator used by Fitzpatrick is rather outside this range.

Applicant believes claims 2 – 14 to be patentable, if only because of their dependence on claim 1.

Applicant respectfully submits that this application is in condition for allowance, and such disposition is earnestly solicited. If the Examiner believes that discussing the application with the Applicant over the telephone might advance prosecution, Applicant would welcome the opportunity to do so.

Respectfully submitted,

  
Avto TAVKHELIDZE  
Inventor